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Wastewater Treatment Plants in rapid mass displacement situations[1]

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7 November 2017

Question

- *When and where have emergency wastewater treatment plants been developed in rapid mass displacement situations and situations of limited space/access?*
- *What models were used, and what were the implications in terms of performance and cost?*

Contents

[1] Part of a series of queries relating to the Bangladesh Rohingya refugee crisis (WASH series)

1. Overview

This rapid review report has identified the wastewater treatment plant (WWTP) options used in emergency settings, with decentralised wastewater treatment systems (DEWATS) and mobile wastewater treatment units performing most effectively and with minimal costs. Examples are taken from refugee camps and internally displaced people (IDP) settlements due to the Iraq war, the Israeli-Palestine conflict, and the civil wars in Syria and Sudan. WWTP options used in Finland, Haiti, Iraq, Jordan, Palestine, Sudan and Turkey are discussed. Lessons learned from China and suggestions for the Rohingya crisis are also included.

A lot of available evidence focuses on water treatment plants, pre-assembled Mobile Water Treatment Equipment (MWTE), or modular water treatment kits (to be assembled in the field) which are used to clean water for drinking in emergency systems, which is not within the scope of this review. The WWTP findings listed are based on peer reviewed journals, global funding agency reports, as well as grey literature. Model information is taken from global manufacturers specialising in WWTP production, however, there is a paucity of information describing models used in specific settlements/refugee camps in low-income/slum areas. Senior experts consulted for this review confirm that there are very little published evaluations on affordable wastewater treatment plants used in emergency settings. Although there are reports of camp areas specifically for women and children, most wastewater treatment plants are in settlements and sites to be used by both genders, therefore the data included in this review is gender-blind. No specific data searches were made for disabled WWTP users.

2. Wastewater treatment plants (WWTPs): options and models for emergency settings

Wastewater treatment plants (WWTPs) remove contaminants from wastewater[2]. The treatment to remove these contaminants includes physical, chemical, and biological processes to produce environmentally safe treated wastewater (Grange / HIF – Humanitarian Innovation Fund, 2016: 10).

Adequate sanitation provision is vital to promote health and prevent the spread of disease from wastewater in long-term temporary settlements such as refugee camps. As sites tend to be overcrowded, facilities can be far from adequate. The WWTP options and models are available for situations of limited space or access are listed below:

Technological options

Although many technologies have been developed and used for greywater[3] treatment and recycle, e.g. membrane filtration (carbon), water polishing (ozone), or ultraviolet (UV) irradiation, the choice of the technology is dependent on several influences. These include cost-

[2] Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It can originate from domestic, agricultural, and/or industrial activities (Grange / HIF, 2016: 10).

[3] Greywater (or sullage) - Wastewater from personal washing (e.g. sinks, showers, baths), laundry washing, food preparation, and cleaning kitchen utensils; does not include sewage flows or excreta from toilets (Sönmez et al., 2011: 2).

effectiveness, the purpose of the water after treatment, and operation and maintenance requirements (Laine, 2001 in Mizzouri et al. 2017: 185):

Decentralised approaches

DEWATS

In many developing countries, centralised sewerage and wastewater treatment systems cover only a portion of larger urban areas, and are often not yet planned for smaller towns and densely populated, low-income areas of cities. On-site sanitation is often inappropriate in the denser settlements and slum areas, thus requiring intermediate and complementary solutions. Decentralised wastewater treatment systems (DEWATS), connected to simplified sewer systems or communal sanitation centres, have the potential to close the gap between on-site and centralised systems. Community-managed DEWATS offer the possibility of swift sanitation improvements in high priority neighbourhoods that communities can manage themselves, where local government does not yet provide a full sanitation service (Eales et al., 2013).

Package plants

Temporary decentralised approaches for wastewater treatment are also known as a "package plants." They can include membrane, pressure, sand or other methods in their treatment: suitable technological options can be chosen depending on geological characteristics (Libralato et al., 2012 in Sharmin, 2016: 27).

Fixed-bed technology - multiple treatments

Primary, secondary and tertiary treatments are needed to manage wastewater. The primary stage is needed to remove settleable solids from the wastewater/effluent (i.e. through septic tanks); the secondary stage is needed to remove nitrogen, phosphorous and pathogenic organisms from the wastewater and can include different treatment options such as natural or man-made (constructed) wetlands, sand filters, facultative lagoon or wastewater ponds[4]; the final of the three treatments is mechanical secondary clarification to separate biomass, which can include filtration and UV radiation (Massoud et al., 2009; Kadlec & Wallace, 2009: Singh / UN-Habitat, 2010: 20). Advantages of fixed-bed technology include the need for minimal oxygen in the wastewater; no need for expensive separators or long setting times, and the fact that wastewater can flow in gradual free-flow through the treatment.

[4] Manmade wetlands are known as constructed wetland (Kadlec & Wallace, 2009). Constructed wetland is one of the popular technologies for secondary treatment in on-site decentralised systems. Stabilisation ponds or lagoons have been used for treatment of wastewater for over 3,000 years (EPA, 2011: xxv). Ponds can be used alone or in combination with other wastewater treatment systems, and have lower operational and maintenance costs (Kadlec & Wallace, 2009; EPA, 2011: 1). Lagoon systems are holding and/or treatment ponds provided with artificial aeration to promote the biological oxidation of wastewater and faecal sludge (Grange / HIF, 2016: 9).

Models

Most available wastewater treatment models are portable and tailor-made for specific site requirements. They are useful in refugee camps with fluctuating populations. Examples of WWTP models are listed below:

Compact systems

Compact WWTP systems can be used in small-scale remote settlements. They are designed for population equivalents (PE) of 50-1,000. Two examples of these are the German-based DELPHIN® Classic and Combi series: The Classic series consists of up to 8 monolithic polyethylene tanks for under- or over-ground installation and can operate at facilities with connection sizes up to 220 PE. The Combi series has a highly adaptable design, and can be installed behind existent primary settlement basins at facilities with connection sizes up to 640 PE. Another model is the UK-based WPL Hybrid-SAF™ WWTP unit, which can operate as an individual treatment plant or be designed to connect in series to form a larger plant, which takes in to account the footprint of each individual site requirement.

Container units

Container WWTPs are fully pre-assembled biological systems. The internal tanks of the container plants are manufactured entirely out of wastewater-resistant polyethylene plastic. As well as the simple transport of the plant to any place in the world, intermodal containers also serve to protect the internal self-supporting tanks and technical installations against external influences i.e. they can be temperature regulated for use in either cold or hot areas. Therefore, even the most challenging conditions do not affect the service life of the plant. They are easy to operate and therefore do not need specialised operational staff. Fast coupling systems and perfectly fitting installation materials, like pipes, hoses and cables, allow an easy set-up and immediate service after positioning the container at the place of operation. Examples that are suitable for refugee camps include the DELPHIN® Container and WPL SAF tanks.

Modular systems (small-scale)

Modular systems e.g. DELPHIN® cube for decentralised wastewater treatment use fixed-bed technology based on different microorganisms, which naturally occur in domestic wastewater. This technology allows the system to adapt to changing conditions, when necessary. As this system can be operated purely by gravity flow, it involves minimal maintenance and reduced follow-up costs. It can treat up to 300 PE- although the DELPHIN® combi-cube[5] can treat up to 1,200 PE. The WPL HiPAF® modular system can also treat up to 2,000 PE where mains drainage is unavailable.

[5] If there is already a mechanical treatment on site that merely needs to be supplemented with biological treatment, it is possible to combine the fixed-bed reactors and a secondary clarifier with the existing mechanical treatment stage(s), hence the term 'combi-cube'.

3. WWTPs in situations of rapid mass displacement and situations of limited space/access

Wastewater is an increasingly critical, and often overlooked, element of refugee camps. In many fast-growing small and medium sized cities (cities with populations < 500,000) wastewater infrastructure is non-existent, inadequate or outdated (Singh / UN-Habitat, 2010: 3). Modern wastewater treatment facilities are almost unheard of in refugee camps, due to limited budgets and lack of time to establish proper facilities (Fisher, 2016), as the following examples highlight:

Finland

In 2015, the number of people seeking asylum in the European Union rapidly increased due to the Syrian refugee crisis. One of the countries receiving tens of thousands of migrants over a few months was Finland. Over 30,000 refugees and asylum seekers were hosted in refugee centres that were established rapidly in existing, unused facilities, such as camp centres and old school buildings. The provision of adequate sanitation services for the displaced populations demanded *reconstruction, re-design and adjustments of the existing wastewater treatment infrastructure* (Kosonen & Kim, 2017). Several *small-scale WWTPs* were *refurbished* to accommodate the increased demand for treatment; which minimised the costs.

Haiti

Port-au-Prince

Port-au-Prince is one of the largest cities in the world without a centralised system to treat sewage[6]. There are no sewers connecting sinks, showers and toilets to large WWTPs. Most of the three million people in the metropolitan area use outhouses, and much of that waste ends up in canals, ditches and other unsanitary dumping grounds where it can contaminate drinking water and spread disease.

After Haiti's magnitude 7.0 earthquake in January 2010, due to the lack of a central WWTP, poor drainage systems led to flooding around urbanised areas of the capital. The catastrophe resulted in an unprecedented level of humanitarian aid totalling approximately USD 13 billion in donations and pledges. Nevertheless, cholera affected more than 720,000 Haitians and killed almost 9,000 between 2010 and 2015 (Bharti et al., 2015; Hooper, 2015 in Tota-Maharaj / HIF, 2016: 22-23).

A sewage and wastewater treatment plant did open in May 2012, with aid from the Spanish Cooperation Agency for International Development (AECID). However, the facility operated for just 18 months before a technical problem - huge bubbles in the lining of the second waste treatment pool - forced it to close. Since then, it has remained closed. DINEPA[7] plans to spend an additional USD 617,000 to repair it starting in autumn 2017 (Hersher, 2017). There are no updates on any progress available as yet.

[6] Sewage or blackwater can be defined as municipal or domestic wastewater, containing bodily or other biological wastes e.g. from toilets and laundry (Sönmez et al., 2011: 2; Grange / HIF, 2016: 8-9).

[7] Haiti's national water and sanitation agency: Direction nationale de l'eau potable et de l'assainissement.

Iraq

Kurdistan region, Duhok

In July 2015 BORDA[8] completed four *DEWATS plants* in three camps for internally displaced people (IDP) and refugees in the Kurdistan region of Iraq, serving around 4,100 men, women and children (BORDA Newsletter, 2015). In the same year, the Japan International Cooperation Agency (JICA) signed loan agreements with the Government of the Republic of Iraq to support low-cost wastewater treatment facilities in Erbil, Dohuk, Sulaimaniyah and Halabja. Most cities in Iraq do not have adequate WWTPs. Even in cities and communities with treatment systems, many have fallen into disrepair after years of neglect. The project is due to be competed in December 2023 (JICA, 2015a). In 2016, British water engineering company Biwater International was awarded a USD 1.2 billion contract by the Kurdistan Regional Government to meet vital water supply and sanitation needs. Biwater will deliver water and wastewater treatment solutions for the cities of Erbil and Sulaimaniyah, where the Kawergosk and Arbat refugee camps are located, respectively. Works will alleviate the current strain on existing infrastructure and reduce the region's reliance on dwindling groundwater reserves.

These international deals are timely as a twelfth camp in the region had to be opened in May 2017 due to people fleeing the fighting in western Mosul - less than four weeks after the United Nations Refugee Agency (UNHCR) opened the Hammam al-Alil 2 camp, which has a capacity for 30,000 people and is now almost full (UN News Centre, 2017). Latest reports show that the rehabilitation of a WWTP in Hilla in Babil has also started (JCMC, 2017: 4). This will benefit 244,000 residents and 3,000 IDPs.

Jordan

Currently, over 64% of the Jordanian population is connected to a sewerage system and raw wastewater is conveyed to 27 WWTPs; of these, 22 have *mechanical* treatment processes, and five use *natural* treatment processes (USAID Jordan, 2014: 7). The provision of adequate sanitation services for displaced populations have demanded reconstruction, re-design and adjustments of the existing wastewater treatment infrastructure in Jordan (Kosonen & Kim, 2017). The Azraq and Za'atari refugee camps became among the first in the world to have on-site advanced WWTPs (Kosonen & Kim, 2017):

Azraq Refugee Camp

The Azraq Refugee Camp in central Jordan currently houses more than 45,000 refugees from the Syrian civil war. However, the camp has the potential to become one of the largest refugee camps in the world: it is reported that preparations are underway to more than double the size of the camp (Fisher, 2016).

Unlike other refugee camps, which simply use pit latrines and cesspools, the Azraq Refugee Camp is the second refugee camp in the world to use a *modern wastewater treatment system* (Huynh, 2017). Within the refugee camp, neighbourhood blocks contain showers and wash stations designed to serve 16 families each (Fisher, 2016). The wastewater is pumped every 2-3 weeks and transported by truck to the WWTP located inside the camp boundaries. Eventually,

[8] BORDA: the Bremen Overseas Research and Development Association.

the treated wastewater will be repurposed for agricultural uses in the arid region. With limited financing for a wastewater system, decommissioned reactor *container units* were recovered from a UN base in Afghanistan and shipped to the camp, where they were refurbished. Once the containers could hold water, a fixed-film biological treatment process was implemented to remove carbon and nitrogen and to separate solids from the wastewater.

Za'atari refugee camp, Mafraq

With a population of over 80,000 women, children and men, Za'atari is one of the largest refugee camps in the world (UNICEF Children of Syria, 2015). In January 2013, severe weather conditions across northern Jordan, including heavy rain, snow and sub-zero temperatures, resulted in widespread flooding, swamping tents and overwhelming the drainage system across the camp (Tota-Maharaj / HIF, 2016: 21-22).

To help this problem, the Jordan Ministry of Water and Irrigation and UNICEF launched a cost-efficient *Mobile Wastewater Treatment Unit*[9] in the Za'atari refugee camp in 2015 (UNICEF Children of Syria, 2015). This WWTP treats 80% of the waste water generated in the camp (UNHCR Factsheet, 2016: 2). Approximately 30 trucks transport over 2,000 metric tons of wastewater to the Al Akaidar treatment plant about 45km away from the camp daily (UNICEF Children of Syria, 2015). The wastewater trucking operation costs UNICEF approximately USD 3.6 million annually. According to the experts consulted for this review, the introduction of the Mobile Wastewater Treatment Units has cut costs by almost five times, to about USD 700,000 a year.

The construction of the Mobile Wastewater Treatment Units took about seven months to complete and was spearheaded by the Ministry of Water and Irrigation and UNICEF, under the direct management and supervision of the Water Authority of Jordan (WAJ). The project is funded by the Government of Germany (implemented by KFW, the government-owned development bank), the Governments of Japan, United Kingdom and the United States, as well as the European Commission's Humanitarian Aid and Civil Protection department (ECHO). Besides being a cost effective and sustainable water treatment system, the mobile units will decrease the number of trucks plying inside the camp, contributing to the overall improvement of the Za'atari camp environment – reducing pollution, as well as the risk of traffic accidents. Plans are also underway to use the treated water for irrigation of alfalfa and other crops.

To improve rapidly constructed WWTPs at other refugee camps in Jordan, a team of University of Washington (UW) College of Engineering researchers is currently working with UNICEF, who help with maintaining access, as well as staff and students from the Jordan University of Science

[9] The Mobile Wastewater Treatment Unit comprises of two independently operated units which work in tandem. The Trickling Filter (TF) unit trickles pre-settled wastewater over a biological filter, and as the water migrates through the pores of the filter, organics are degraded by the biofilm which covers the filter material. The second unit called the Membrane Bio Reactor (MBR) has micro filters membranes that separates out liquid from solids. The combined daily treatment capacity of the two units is approximately 3,500 metric tons, more than adequate to treat wastewater from the camp.

and Technology (JUST), with aid from a National Science Foundation Rapid Response Research grant. They hope to publish their findings in the near future (Fisher, 2016).

Conversely, not all refugees live in designated camps in Jordan; the rest reside in cities and villages such as in Mafraq. Mafraq was a provincial capital of 60,000 people in northern Jordan, about 15km from the Syrian border. However, now the total population has grown to 200,000 (Jordan Times, 2015). Mafraq's existing WWTP, approximately 6km north of the city, utilises *stabilisation ponds* for wastewater treatment on a 37-hectare (ha) site. The plant began operating in 1988 and has consistently failed to meet Jordanian standards for stream (wadi) discharge. Today, the equipment is seriously deteriorated, and inflowing sewage exceeds the design capacity (USAID, 2017). In 2011, USAID supported a feasibility study and design for upgrading the existing WWTP, and is currently funding construction and management to upgrade the plant to a capacity of 6,550 m^3 per day through simple, low-tech improvements. Treated water from the facility will be used mainly for irrigating farms in the plant vicinity. The WWTP has been designed to serve the city of Mafraq until the year 2025 (USAID, 2017).

Palestine

Aqbat Jabr refugee camp, Jericho (West Bank)

As part of the 'Jericho Wastewater Collection, Treatment System and Reuse Project' the Jericho WWTP was opened in 2014. The wastewater generated in the urban areas of Jericho was unable to discharge to open areas due to the topographic conditions and a contaminated aquifer in the Great Rift Valley. Considering the current and future growth of the population in Jericho and surrounding areas, a wastewater treatment system to secure the water resource was crucial (JICA, 2014).

'An Overview of Wastewater Management Practices in the West Bank' (Joudeh, 2015: 4) revealed that 15% of the collected wastewater in the West Bank is treated in wastewater treatment plants. There are five major WWTPs using different systems (compared in Table 1 below), 13 smaller WWTPs[10], and more than 700 small-scale on-site WWTPs[11]. There is no renewable energy use, in the major or small plants. The technical capacity of most plants in operation is exceeded, and there are no reuse schemes/systems for treated effluents (Joudeh, 2015: 22).

[10] These plants are: Kharas, Nuba, Bani-zeid, DeirSamit, Hajja, Attil, Zeita, Sarra, BiddyaSir, Biddya, EinSiniya and Nahhalin. Their capacities range from 10-120m^3/d. These plants employ preliminary and some primary sedimentation basins. Most of these plants are overloaded (Joudeh, 2015: 18).

[11] On-site small-scale wastewater treatment plants have been established in several rural localities of the West Bank (Joudeh, 2015: 19). An on-site treatment plant can serve a single house or a cluster of houses. According to surveys by Palestinian Water Authority in 2011, most of these on-site plants are not working effectively.

Table 1: A comparison of major WWTPs in Palestine using different treatment systems

Treatment plant	System used	Pros	Cons
Nablus West	Conventional activated sludge system Main plant units: Mechanical sludge thickening unit; Preliminary sedimentation tank; Primary thickener; Gas holder and Gas flare; Sludge drying basin, and Liquor storage tank	Capacity (Q)= 15,000m^3/day, actual flow < 11,000m^3/day	Technical problems e.g. management of drying basins
Jenin	Aerated lagoons	Q= 9,250-14,000m^3/d, actual flow 2459m^3/day	None stated
Al-Bireh	Extended aeration with mechanical solids handling, simultaneous aerobic sludge stabilisation and sludge drying by pelt filter press	Q= 5,750m^3/d (dry weather flow), actual flow 6,500m^3/day	Technical problems e.g. flow beyond the flow plant capacity, and low treatment efficiency and sludge accumulation
Ramallah	Extended aeration treatment	Q= 1,500m^3/d, actual flow 2,200m^3/day	Low efficiency
Tulkarm pre-treatment	Stabilisation ponds	Q= 15,000m^3/d, actual flow < 7,120m^3/day	Technical problems e.g. low efficiency and sludge accumulation

Source: Joudeh (2015: 5-15)

Because of the poor performances of these WWTPs, approximately USD 6.5 million was donated to support the construction of a sewerage network in the Aqbat Jabr refugee camp in the West Bank in September 2017. The sewerage network will be constructed in collaboration with JICA and will be connected to the Jericho WWTP, also constructed by JICA. This assistance is made in addition to Japan's support to Aqbat Jabr refugee camp in 2016, and allows the Agency to cover the camp's entire sewerage network (Reliefweb, 2017). Treatment plants are likely to be located close to agricultural lands in Hebron (second largest agricultural area after Jenin – which is performing better than the other plants) and Nablus East (Joudeh, 2015: 21).

Sudan

Multiple camps, Darfur region

The African Union / United Nations Mission in Darfur (UNAMID) collaboration has installed 122 WWTPs at its camps across the Darfur region. These use an *activated sludge treatment process* to treat wastewater generated in UNAMID's various locations to a level acceptable for reuse as recommended by the World Health Organisation (WHO). This treated wastewater is used as a substitute for fresh water to meet the non-potable water demands of the Mission's personnel e.g. toilet flushing, tree planting, car washing, construction works, dust control and firefighting - and has reduced the need for fresh water in the Mission's camps where these systems have been installed by 40% (Mohammed / UNAMID, 2016). The trees planted near UNAMID's camps are also watered with treated wastewater. No information is available evaluating the use of the facilities by refugees, however, which are said to number 2.3 million in total according to government figures.

Turkey

Southeast region

Since the Syrian civil war began in 2011, the number of Syrians who have flowed into Turkey has reached 1.75 million as of April 2015 according to Government of Turkey figures. However, barely 10% of these Syrians stay in camps (JICA, 2015b). This large-scale influx has had a major impact, reducing the level of services the municipalities (local authorities), such as water, wastewater, and solid waste management. This left local authorities with no choice but to accelerate their infrastructure development plans.

In 2015, funding was agreed for a project to provide the long-term financing until 2023 needed for infrastructure development in such local authorities located in southeast Turkey, where there has been the largest influx of Syrians. The funds were allocated to investment in the improvement water treatment plants, water transmission, distribution lines, WWTPs, collectors, sewerage pipelines, storm water drains and solid waste disposal sites; as well as procurement of operation and maintenance equipment, and consulting services (assistance for feasibility studies for the facility improvement) (JICA, 2015b). The contract for Akşehir – in Konya province, Central Anatolia (southeast Turkey) – was won by Spanish-based ACCIONA Agua. It represents a budget of 10.4 million euros (USD 12.1 million), with the project consisting of two phases: the first involves the design, engineering and construction of the plant, with a wastewater treatment capacity of around 15,000m^3 per day to provide a service to a population equivalent of around 65,000. The plant may be extended in a second phase up to 18,000m^3 / day to provide a service to 80,000 people. The project will also cover the construction and rehabilitation of around 36 kilometres of wastewater piping.

4. Lessons learned

- Package WWTPs are far less common in humanitarian situations, as they are much higher in price and complexity than is considered feasible for the humanitarian context.
- The system may need to fit on a plane/be transported by sea, or be capable of handling high chlorine content in the wastewater if used in cholera treatment centres. Ease of use is less of a priority, although requirement of technical specialists is acceptable (Carter / IFRC, 2015).
- Some experts believe that humanitarian interventions should be moving away from refugee camps altogether, and argue that necessary policies should favour integrating refugees into existing urban areas, where integration into host countries is more

seamless and where refugees are not isolated in a camp where they must rely on foreign aid for stability (Huynh, 2017). This will mean more interaction with local governments when planning WWTPs.

- Energy is a major contributor to the cost of producing water and treating wastewater; it can represent over 30% of annual operations and maintenance expenses in a typical water treatment plant, and between 25 and 45% of operations and maintenance expenses in WWTPs (Smith & Liu, 2017: 1). China is an example to use for studying such costs: its daily wastewater treatment capacity approximately doubled between 2007 and 2013, and energy use for wastewater treatment almost doubled between 2008 and 2013 (Smith & Liu, 2017: 1). Energy use for sludge treatment and disposal is likely to be similar to that for WWTPs (Smith & Liu, 2017: 3).
- Biological treatment is the main energy user within WWTPs in China, with aeration being the major energy burden. The scale of wastewater treatment can affect energy use and the most energy efficient scale depends on the type of secondary treatment technology used (Smith & Liu, 2017: 6).

Advantages of using DEWATS in the Rohingya crisis

Decentralised on-site wastewater treatments can be implemented with low cost funding as some available facilities can be used as alternatives:

- Septic tanks are available in most areas, and these could act as a pre-treatment to wastewater treatment. Therefore, cost for an additional pre-treatment facility could be reduced (Sharmin, 2016: 27).
- Abandoned ponds in villages could be used as stabilisation ponds. Such things will make decentralised wastewater treatment facility easier to implement in small villages of Bangladesh (Sharmin, 2016: 27-28).
- Environmentally, the decentralised wastewater treatment system is an appropriate option for small villages with relatively low population density (Massoud et al., 2009; BORDA, 2010). This can include recycling water or re-using biogases released during the treatment.
- DEWATS applications are based on the principle of low-maintenance since most important parts of the system work without technical energy inputs and cannot be switched off intentionally: DEWATS applications provide state-of-the-art-technology at affordable prices because the materials used for its construction are locally available (Singh / UN-Habitat, 2010: 15).
- Another significant feature of decentralised system is the overcoming of various geological problems: types of on-site facilities can be made according to groundwater tables, soil and bed rock condition. If a particular site is hard to access, the system can be adjusted to meet its treatment goals (Massoud et al., 2009).
- Decentralisation allows flexible management. Compared to centralised treatment, decentralised systems require less skilled labour to operate and maintenance. Therefore, this on-site system can be an appropriate option for village habitants, where skilled workers are lacking (Libralato et al., 2012).
- The biological treatment of wastewater without technical energy inputs by DEWATS applications makes wastewater meet basic hygienic needs in refugee camps and allows proper disposal to meet environmental standards (BORDA, 2010).

Disadvantages of using DEWATS in the Rohingya crisis

- Acceptance by the users of a treatment system is important. A well-designed system could work less effectively if the public misuse it. People in rural areas may not be well educated to understand the concept and advantages of decentralised wastewater treatment system (Sharmin, 2016: 27).
- Vast space requirements for the on-site system could be an issue. The land might be prioritised for agricultural purposes rather than for treatment purposes (Sharmin, 2016: 27). Although small-scale plants are available, the costs associated with them may be off-putting.
- Cost is one of the main issues. People may not agree to invest more in the wastewater treatment if they already have existing septic tanks. It may be difficult to introduce a change in the present system, especially if it has been used for several years (Sharmin, 2016: 27).

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Acknowledgements

We thank the following experts who voluntarily provided suggestions for relevant literature or other advice to the author to support the preparation of this report. The content of the report does not necessarily reflect the opinions of any of the experts consulted.

- Andy Bastable, Oxfam Global Humanitarian Team
- Caetano Dorea, University of Victoria (formally at Université Laval)
- Miraj Phadhan, UNICEF Jordan Country Office

Suggested citation

Tull, K. (2017). *Wastewater Treatment Plants in rapid mass displacement situations.* K4D Helpdesk Report 230. Brighton, UK: Institute of Development Studies.

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